Overview of the LLNL SPE R&D and Analysis Activities

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Lawrence Livermore National Laboratory

State of Analysis Review

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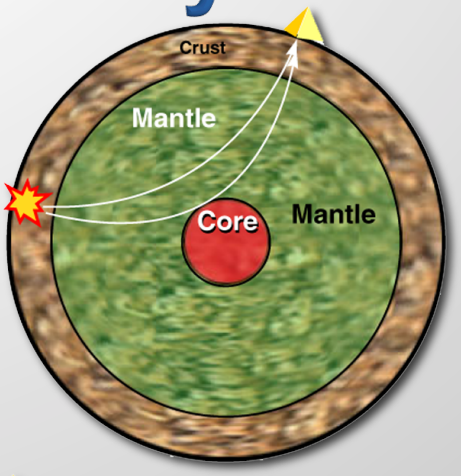
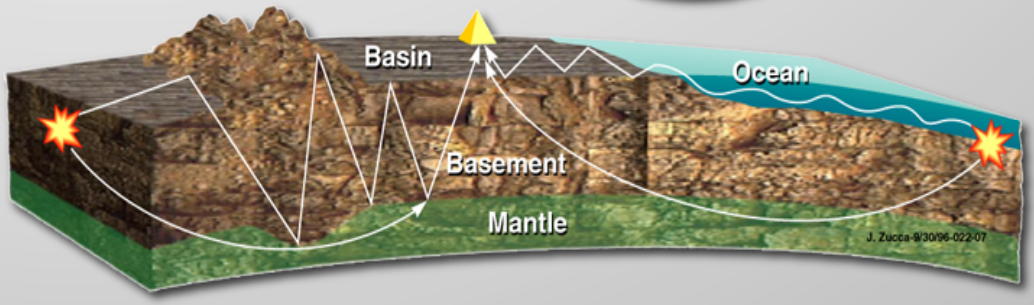
Seismic monitoring is currently a semi empirical science

- The best monitoring is where there are regional calibrations
  - Capability degrades to teleseismic level away from the calibrations
  - Some areas of interest do not have calibration
- NEED: the capability to predict the observed signal from an arbitrary source for an arbitrary receiver
  - Three Dimensional Earth Model
  - Source model that predicts P- and S-wave excitation
- Current numerical simulation capability does not yet explain all the past nuclear data including
  - Generation of S-waves (including Love and reversed Rayleigh waves)
  - Effects of media and emplacement conditions on seismic waves





Source Physics Experiments at NNSS will provide critical data to develop predictive capabilities for low-yield nuclear test monitoring

Based on historic testing we have a good empirical understanding of ID algorithms but lack physics-based predictable models

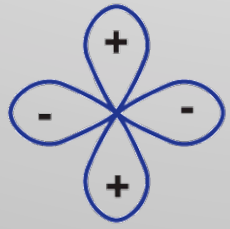
Earthquake

Shear slip on a plane

S-wave energy dominates

Strong Love waves

Rayleigh & P-wave radiation pattern

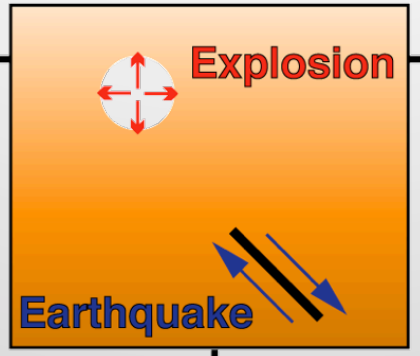


$m_b \sim M_s$

P/S < 1

Double-couple

$$\begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$



Explosion

Pressure pulse on a sphere

P-wave energy dominates

No Love waves

Constant Rayleigh & P pattern

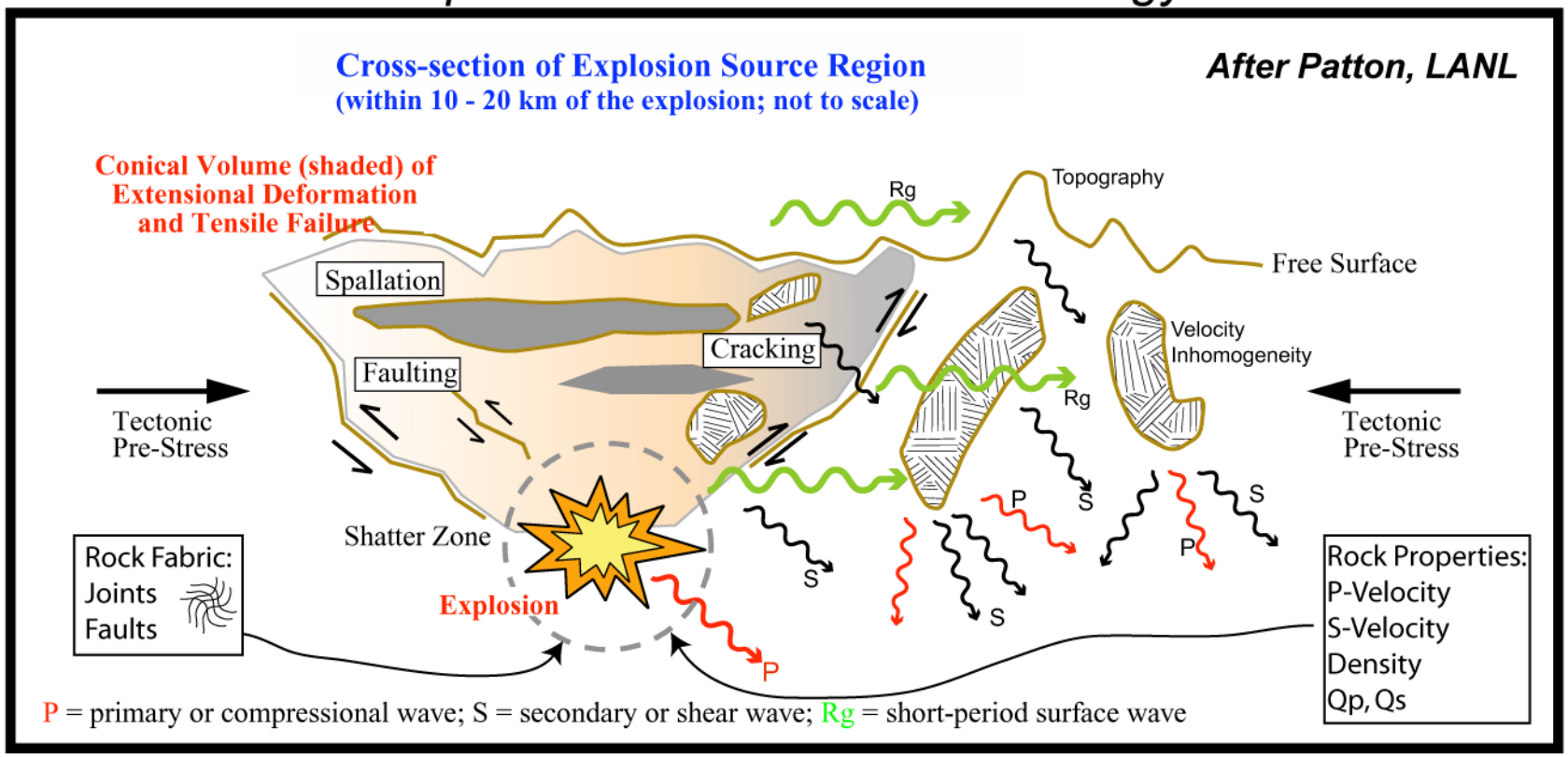
$m_b > M_s$

P/S > 1

Isotropic

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

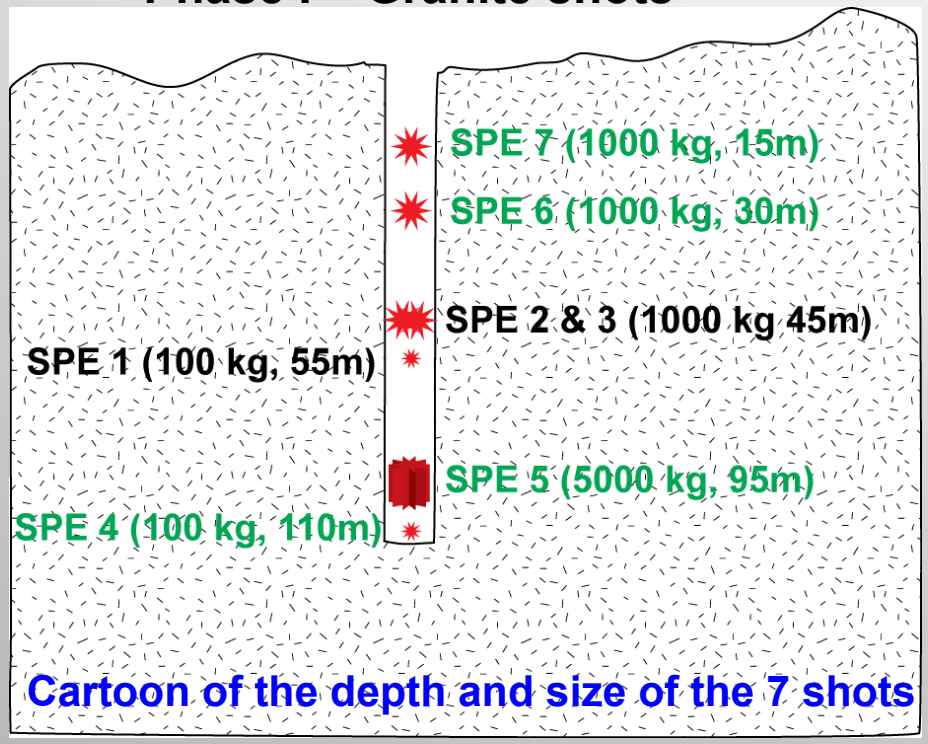
The monitoring community does not currently have an accepted model for explosion S-wave generation



Many potential sources but no quantifiable physics-based model

The SPE is a bridge from current test site empirically-based monitoring to a more worldwide Physics-based Monitoring

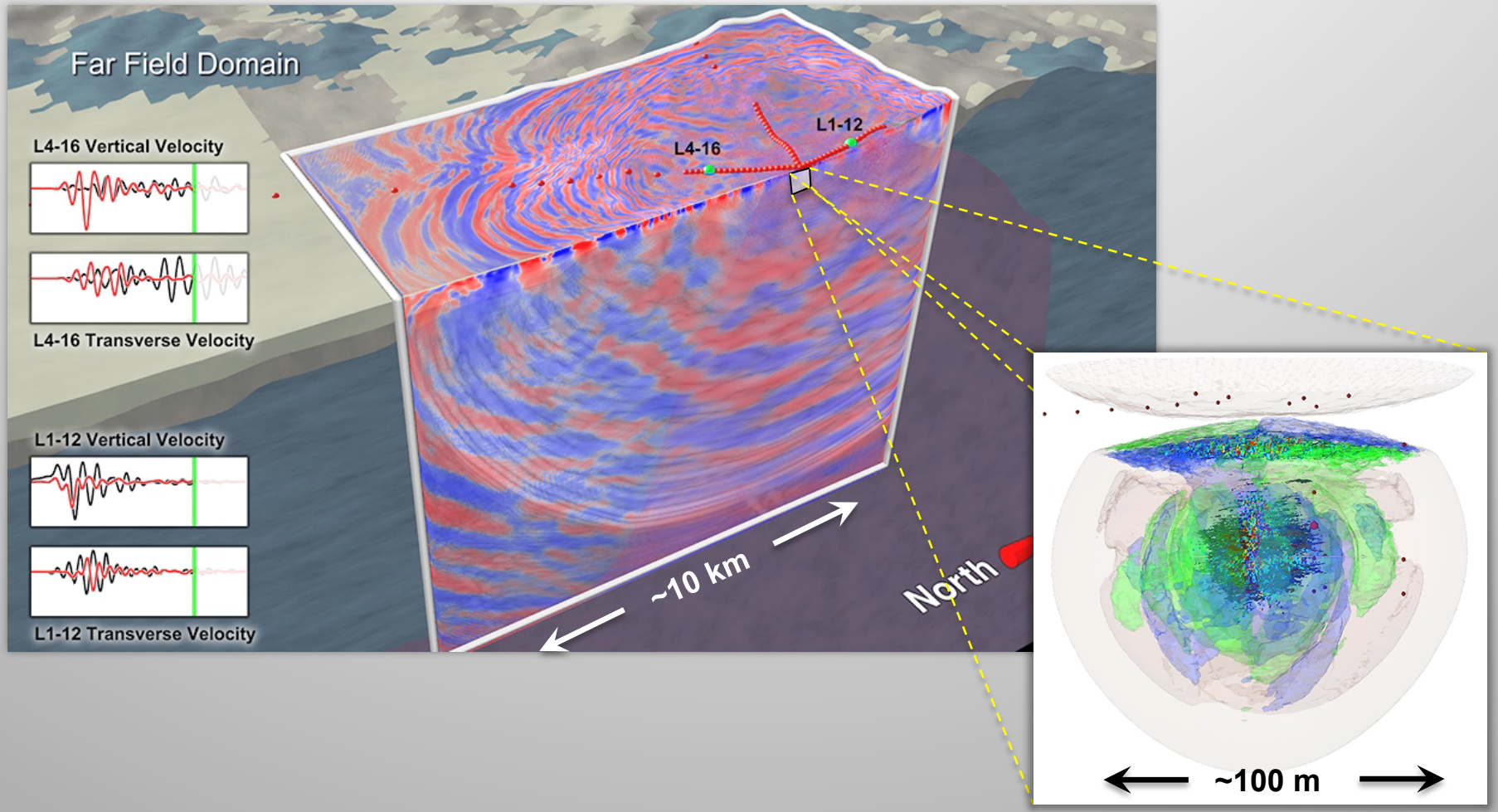
Phase I – Granite shots



Shot Name	DOB[a] (m)	SDOB[b] (m)	Yield (Kg TNT)	Origin Time	Short Description and Scientific Basis
SPE-1	54.9	991	85	3 May 2011 22:00:00.011	Initial ~Green function (GF) shot in a simple geology. Simulation capability R&D for non-isotropic effects.
SPE-2	45.7	364	992	24 October 2011 19:00:00.012	Increase shot size to record signals to 100km Investigate depth of burial (DOB) effects with SPE5&6
SPE-3	45.8	377	899	24 July 2012 18:00:00.447	Investigate damage zone effects relative to SPE2
SPE-4	110[c]	TBD	TBD	TBD	Minimize spall, ~GF for SPE 5, DOB relative to SPE1
SPE-5	100[c]	TBD	TBD	TBD	Increase shot size to record signals to 300 km
SPE-6	30[c]	TBD	TBD	TBD	DOB investigation with SPE2&7, middle depth
SPE-7	15[c]	TBD	TBD	TBD	Final granite SPE, standard DOB for nuclear test shot

Solution: a series of Source Physics Experiments to provide the necessary physics-based model development and validation data

A fully coupled source-to-sensor modeling capability is being developed and applied to address the major scientific goals of SPE



Time	Title	Presenter
8:05	LLNL Overview	Tarabay Antoun
8:20	Discrete and continuum simulations of near-field ground motion from the Source Physics Experiment	Oleg Vorobiev
8:50	Stochastic three-dimensional investigation of near-source motions from an underground explosion	Souheil Ezzedine
9:20	Analysis of recorded and simulated far-field ground motion from the source physics experiment	Arben Pitarka
9:50	SPE Animation	
10:30	Explosion and spall model comparison with the Source Physics Experiment	Sean Ford
11:00	SPE signals and setting: EM, seismic amplitudes and velocity models	Rob Mellors